Ohio Agricultural Experiment Station.

BULLETIN 105.

WOOSTER, OHIO, APRIL 1899.

FURTHER STUDIES OF CUCUMBER, MELON AND TOMATO DISEASES.

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EXPERIMENT STATION, WOOSTER, OHIO.

COLUMBUS, OHIO
FRED J. HEER, STATE PRINTER
1899

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The Bulletins of this Station are issued at irregular intervals. They are paged consecutively, and an index is included with the Annual Report, which constitutes the final number of each yearly volume.

Bul. 105

BULLETIN

OF THE

Ohio Agricultural Experiment Station.

NUMBER 105. APRIL, 1899.

FURTHER STUDIES OF CUCUMBER, MELON AND TOMATO DISEASES, WITH EXPERIMENTS.

BY A. D. SELBY.

CONCERNING CUCUMBERS.

As pointed out one year ago, certain diseases were then prevalent upon cucurbits and tomatoes.* These same distinctive fungous parasites have again appeared during the season of 1898, reënforced, to a certain extent, by minor cucurbit diseases not previously observed in Ohio. The pickle industry has continued to enlarge in Wayne county and has extended into others, notably into Portage and Ottawa counties. Melon growing has somewhat regained its yielding position, while tomato canneries and preserving works make increasing demand for that product.

Studies for the season just closed were undertaken with a view to the control or prevention of the prominent diseases of the crops named, as well as to discover what might be new in this line. Practical control of the fungous enemies of these garden crops was kept as a major aim in these investigations. In fact the conditions of 1897, coupled somewhat with those of previous seasons, brought the growers of muskmelons and cucumber pickles to consider the abandonment of these crops. In the studies made the writer was cordially assisted by many growers, whose names appear elsewhere; by the Horticultural Department of this Station, and by Mr. J. W. T. Duvel, Assistant Botanist.

* Bulletin 89, December, 1897.

WEATHER CONDITIONS OF 1897 AND 1898 COMPARED.

The statistics of rainfall and temperature for the growing seasons of 1897 and 1898 are given in Table I. From it the comparisons may be readily made. First as to temperature:—In 1897, April, May and June gave a mean temperature 1.2, 3.9, and 2.° respectively below the normal for those months, May being the coldest for 15 years. The other months, excepting only August, which was 1.° below normal, gave temperatures above the average. In 1898, on the other hand there was a single month below normal, namely April, which was 3.° below, while all the others were warmer than the average or normal. May and June in succession were both above.

When rainfall is considered, the favorable conditions in 1898 over those of 1897 are again apparent. These consist in the fine distribution of the rain throughout the growing season and in the abundance of rain in August, 1898, followed by a normal September rainfall.

TABLE I—TEMPERATURE AND RAINFALL, MARCH TO SEPTEMBER, 1897 AND 1898.

Month.	Temperature.				Rainfall.			
	1897.		1898.		1897.		1898.	
	Mean.	Above (+) or Below (—) Normal.	Mean.	Above (+) or Below Normal.	Mean.	Above (+) or Below Normal.	Mean.	Above (+) or Below Normal.
	Degrees.	*Degrees.*	*Degrees.*	*Degrees.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
March.....	41.5	+5.2	45.0	+8.0	5.17	+2.28	6.23	+3.00
April ..	49.3	—1.2	47.2	—3.0	3.27	+0.30	2.38	—0.60
May.....	56.3	—3.9	61.0	+1.0	3.93	—0.05	4.10	+0.12
June.....	68.1	—2.0	71.9	+1.5	2.85	—0.97	2.86	—0.90
July.....	75.5	+2.4	76.0	+2.8	4.65	+1.09	3.98	+0.40
August	69.4	—1.0	73.5	+2.2	2.72	—0.34	4.50	+1.65
September.	66.9	+2.1	67.8	+2.5	0.78	—2.07	2.50	—0.04

The contrasting meteorological conditions for May and June of 1897 and 1898 respectively, have much to tell in the way of the large returns from early planted cucumbers in 1898. It will need to be borne in mind that the combination of two very warm months of May and June in any one year, accompanied by freedom from destructive frosts, is not frequent; therefore, the large returns from early planted pickles may prove disappointingly misleading, if these alone are kept in mind. But to these we will return later.

The distribution of the rainfall throughout the growing season of 1898 left little to be desired in this regard; the same satisfactory distribution of the rain did not occur in 1897.

PICKLE YIELDS IN 1898.

The average pickle yields for 1898, in Wayne county, are still slightly below a fair average yield, and locally decidedly deficient. The information available shows an average yield of about 135 bushels per acre from the 1,050 acres of pickles grown in the county the current season. The lowest average, 125 bushels, came from the Smithville region, where clay soils generally prevail, and from new growers about Wooster; the highest average, 190 bushels, from the Creston Preserving Co's. fields. This association includes a number of experienced growers; their soils planted are for the most part sandy, and accordingly quickly responsive to the high temperatures prevailing.

Under the conditions of the present season, some very large yields were obtained by early planting. Mr. D. H. Harter, of Smithville, on a chestnut ridge soil, produced 450 bushels of pickles from one acre of land, planted May 10th. Mr. I. W. Knestrick, Creston, secured a yield of nearly 300 bushels on a part of his, planted in May. A yield of 228 bushels per acre on the 14 acres of Dr. A. C. Knestrick, Creston, where the spraying reported later on was done, was obtained by planting at the usual time.

DISEASES UPON CUCUMBERS IN 1898.

DOWNY MILDEW.

Downy mildew, *Plasmopara Cubensis* (B. & C.) Humph., was the chief fungous enemy, as in 1897, having been found over practically the whole State. This disease was first observed at Creston, August 13th, and was generally prevalent in Wayne county pickle fields a week or ten days later. In the unsprayed plot of Dr. Knestrick's pickle field it appeared August 19th, and the vines in the plot were nearly all dead September 1st. In most fields picking was stopped during the last week of August. The symptoms and course of the disease were much as described in 1897. The disease spread from the unsprayed to the sprayed plots under experiment, thus showing the inadvisability of leaving unsprayed areas in fields treated for downy mildew. This fungus may apparently be expected in Wayne county during the first half of August in each year. While effort was made to discover in what manner the fungus passes the winter, this was without result. Old vines from the same diseased field of 1897 in which the mildew was first found in 1898, it having been again planted, were brought into the greenhouse in December, being disposed upon the earth, or partly covered with earth beneath growing cucumber plants. No mildew occurred in this greenhouse. Oospores were sought for but without result. In order to test the possible number of cucurbitaceous hosts for this in the order, apparently omnivorous fungus, seeds of many species representing genera of Cucurbitaceæ were planted in the pathological garden of the Station, together with cucumbers, melons, gourds, squashes and Madeira vine,

Boussingaultia baselloides. The list includes the following: Wax-like gourd (*Benincasa cerifera*)*Bryonopsis laciniosa erythrocarpa, Coccinia Indica,* cucumber (*Cucumis sativus*), hedgehog gourd (*Cucumis erinaceus*), rag gourd (*Cucumis acutangulus*), muskmelon (*Cucumis Melo*), pomegranate melon (*Cucumis odoratissimus*), pumpkin (*Cucurbita Pepo*), egg-gourd (*Cucurbita ovifera*), warty squash (*Cucurbita verrucosa*), winter squash (*Cucurbita maxima*), watermelon (*Citrullus vulgaris*), exploding or touch-me-not cucumber (*Cyclanthera explodens*), balsam apple (*Momordica balsamina*), *Momordica charantia,* grape cucumber (*Melothria scabra*), *Mukia scabrella,* and snake gourd (*Trichosanthes colubrina*). All the cucurbits named except the wax gourd (*Benincasa cerifera*) and the exploding cucumber (*Cyclanthera explodens*), were attacked by the *Plasmopara Cubensis.* The Madeira vine was not affected. The wild vines of star cucumber (*Sicyos angulatus*) and of wild prickly cucumber (*Micrampelis* (*Echinocystis*) *lobata*) were also attacked by it, the former rarely, and the latter freely and commonly about Wooster. It will thus be seen that the new hosts are several in number, and the total number large. The facts brought out in this connection increase the probability that the downy mildew will persist in our cultivated cucurbit areas. Diligent search has, as yet, given no information as to the manner in which the downy mildew fungus passes the winter period; that it apparently does so in the regions before infested is supported by the recurrence of the disease in fields where it existed the previous season. With most of the related mildews the winter is passed by resting spores known as oöspores; these are produced in the case of downy mildew of the grape within the leaf tissues of the diseased leaves. With the allied *Peronospora parasitica* on pepper-grass oöspores are produced within the stems attacked by it. But for both the *Plasmopara Cubensis* of these various cucurbits and the *Plasmopara Australis* found commonly here upon wild star cucumber along the streams and in a few instances on the wild prickly cucumber, oöspores are as yet not known. The mildew covering the wild star cucumber, like the destructive disease of the pickle fields, reappears from year to year — in neither instance have we been able to note the manner of survival. In this connection it is to be noted that the mildew of the gardens and fields has not appeared there until after August 1; in 1897 it was known as early as August 18th to 20th, while in 1898 it was found August 13th. Apparently, mildew is not likely to come much earlier, and can scarcely be expected before August 1st. Spraying for downy mildew need not be begun much before that date, and it is obvious from the experience of growers who have planted cucumber pickles earlier in the season, that it is entirely possible to gather a good crop before the mildew appears. The same statements apply to cucumbers for market. It must not be forgotten that the cucumber wilt, anthracnose, and the cucumber beetle, especially the two former, are liable to prove more troublesome upon the earlier vines than upon the

late ones. However, neither of the two diseases just named is usually so rapidly destructive as the downy mildew in its season. As is shown in the spraying experiments, the downy mildew may be prevented by the use of Bordeaux mixture, as recommended in our spray calendar (1899) and it may be escaped, or forestalled, by gathering the cucumber or pickle crop before it joins in the procedure.

ANTHRACNOSE.

The anthracnose, unlike the downy mildew, obviously attacks both stems and leaves. It is due to the anthracnose fungus, *Colletotrichum Lagenarium* (Pass.) Hals. An illustration was given in Bulletin 89. This trouble has evidently been more prevalent than during the previous season. The anthracnose was early in its ravages near Marietta, was present later about Creston (see page 224) and was destructive upon muskmelons, under which head examples are given. It appears to be one of the most destructive cucumber and muskmelon diseases of the early summer. The results of the season support previous statements as to the practicability of controlling the anthracnose by the use of Bordeaux mixture.

CUCUMBER WILT.

Cucumbers and melons frequently wilt down suddenly and die; this is very likely to occur when the plants are forming the earlier vines, although it may be observed later as well. Heretofore but one form of this disease has been observed in Ohio; the past season has apparently added a second one. That known heretofore upon cucumbers, melons, and squashes is referred to a bacterium which is transferred to a greater or less extent by insects from diseased to healthy plants. The microbe in question has been named *Bacillus tracheiphilus* Smith, and it has been quite thoroughly investigated. The part played by insects in scattering this microbe and inoculating it into otherwise healthy plants seems well established; both the cucumber beetle and the squash bug are instrumental in its spread. I have frequently been informed by melon growers that "the wilt comes after the stink bug appears." The germs of the trouble are abundantly produced in the plants affected and are present to be distributed from them. Destruction of the supply of germs and of the distributing insects (squash bug and cucumber beetle) are alike demanded to control the disease. To this end it is well to pull and burn the affected plants. Spraying, except as it drives away insects, is not available to prevent the trouble.

The second wilt disease which appears to be due to the same or a similar fungus to that causing the southern watermelon wilt described by Erwin F. Smith,* was found upon garden cucumbers, the Japanese climbing cucumber and upon muskmelons during the season of 1898.

* Proc. Am. Assn. Adv. of Sci. 1895, Vol. XLIV, p. 190.

The fungus with which we have to do in this case is a species of Fusarium, characterized by the production of three spore forms:—

1. Very small, elliptical, colorless spores (conidia)produced within the living plant. 2. Large, curved or spindle-form, separate spores (conidia) formed in pink or salmon colored masses on the surface of the dead vines. 3. Nearly spherical spores (chlamydospores ?) produced on the surface of the wilted stems. These characters, so far as they go, are nearly those of *Fusarium niveum* to which Smith has referred the watermelon wilt of the south as well as wilt diseases of other plants, namely, sweet potatoes, cowpea etc. The particular case first called to notice was one by Mr. D. H. Willard of Shawnee, Ohio, upon Japanese climbing cucumber. It was afterwards observed on the garden strain and upon muskmelons; for if the disease be different, the studies made up to date do not exhibit the differences. Publication of this note is intended to attract observers to diseases of cucurbits in which pink and salmon colored masses of fungus are found upon the stems killed by such.

A PHYLLOSTICA OF CUCUMBERS — ALSO A CERCOSPORA.

It may be disheartening to the grower, but to the mycologist it is of interest to collect previously unknown parasites upon cucurbit plants or upon plants of any sort. In the present instance notes have been made upon two or three other fungi upon cucumbers; with the possible exception of a *Phyllosticta*, however, these do not appear serious. This has been referred to *Phyllosticta Cucurbitacearum* Sacc. and was very abundant upon the unsprayed plats at Creston, as well as in other pickle fields. It causes brown spotting of the leaves, on the dead areas of which an abundance of small, brown, pycnidia (resembling in form the emblematical beehive) cover the upper surface. *Cerospora Cucurbitae* E. & E. was found in more or less abundance in a rather wet pickle field with the Phyllosticta. Both of these are referred to species already described, although deviations from published characters were noted.

SPRAYING EXPERIMENTS WITH CUCUMBERS.

Considerable effort was made during the season of 1898 to arrange for coöperative experiments in various districts, to demonstrate the value (or lack of value) of spraying to prevent anthracnose, downy mildew of cucumbers, leaf blight and downy mildew of muskmelon and tomato leaf blight. These will be discussed under the separate hosts. The cucumber experiments for prevention of anthracnose were carried on in cooperation with Mr. Chas. P. Dyar of Marietta, Ohio, and were upon early cucumbers.

EXPERIMENTS WITH ANTHRACNOSE.

Experiment of Mr. C. P. Dyar, Marietta. — This was conducted upon 9 rows of early market cucumbers; plants grown in pieces of sod under glass and transplanted to field May 20th. They were set in a

sandy loam and well cared for. Sprayed with Bordeaux mixture, 1st, June 7; 2nd, June 22; 3rd, July 8; 4th, July 23. The unsprayed plot consisted of 1 row in the middle across the area; the sprayed one of 8 rows of equal length. I quote from Mr. Dyar's report of the result.—

"The sprayed rows always appeared somewhat the better. The market for cucumbers stopped suddenly and many were never picked. The yield from 8 sprayed rows was, up to and including July 20, 124 dozens of marketable cucumbers or an average of $15\frac{1}{2}$ dozens per row. The unsprayed row yielded in this time a total of $13\frac{1}{6}$ dozens." As will appear from the reported yields, the productive capacity of the sprayed rows was still undiminished, while the vigor of the unsprayed rows was somewhat impaired. At a slightly later date than the close of picking the difference in the vines was very striking.

CUCUMBER YIELDS — C. P. DYAR.

Date.	8 Sprayed Rows.	1 Unsprayed Row.
July 2	3 dozen 8	1 dozen 4
" 5	3 " 11	10
" 6	9 "	1 " 2
" 7	6 "	10
" 8	14 " 2	1 " 10
" 11	16 "	8*
" 13	12 "	1 "
" 15	18 " 8	2 " 2
" 18	18 " 4	1 " 10
" 20	22 "	1 " 6
Average, per row	15 dozen 6	13 " 2

*On 11th, 10 poor cucumbers were rejected.

The cost of this work was greater than the profits returned for the limited time during which the cucumber market held good. As noted in the experiments at Creston, a localized outbreak of anthracnose was observed, which was kept in check by the treatment.

SPRAYING FOR DOWNY MILDEW ON CUCUMBERS.

Efforts in this line included coöperation with the Horticultural Department of the Station and extended spraying work in the pickle fields of Dr. A. C. Knestrick of Creston, O. The work at the Station could not be planned to yield comparative spraying results, since it was primarily a variety test, but it did give valuable information as to spread of the disease to which later reference will be made. The experiments in coöperation with Dr. Knestrick were on a commercial scale, nearly fifteen acres being sprayed under the direction of the Assistant Botanist, J. W. T. Duvel. The experiment proper included a much smaller area, but through the kindness of Dr. Knestrick we are able to give the detailed yields from about 4 acres of cucumbers, of which 3.8 acres were sprayed 6 times and 0.19 acre was left unsprayed.

This trial was made in a tract of sandy loam or bottom, lying near Killbuck creek and about 1 mile west of Creston, Wayne county, which had been in cucumber pickles for 3 years in succession and the crop had suffered severely from downy mildew in 1897. Upon the north it joined some woodland and the large forest trees made it necessary to eliminate from the experiment four rows of the cucumbers, which were planted in drills seven feet apart. The seed was sown June 17th and 18th, and the plants were subsequently thinned to 6 to 8 inches apart. The annexed diagram will show the situation and areas of the sprayed and unsprayed plots from which harvest records were made:

DIAGRAM OF DR. KNESTRICK'S NORTH CUCUMBER FIELD.

N.

Sprayed — Not otherwise included in experiment.

I. Unsprayed — 2 rows. .19 acres.

II. Sprayed six times.

July 18–19; Aug. 1–2; Aug. 12–13; Aug. 23; Aug. 31; Sept. 7–8.

*Mildew Aug. 23.

W. E.

Area — 40 rows. 3.8 acres.

b b

b

b o b

III. 3 rows — first spraying omitted, July 18–19.

S.

The asterisk in Plot II indicates center of a mildew outbreak, August 23. The point marked o in middle of field at south, shows location of anthracnose outbreak, first observed August 1; this point continued the center of the anthracnose development which had extended to the points b, b, by September 1.

Two tabulations have been prepared to give the results of the experiments on the plots outlined above and including besides the spraying cost on the entire area sprayed.

The Bordeaux mixture was of the 75 gallon formula, or Bordeaux 1 of our spray calendar,* having 4 pounds of copper sulfate with 4 pounds lime to 50 gallons of water. Excepting for the first spraying, when a simple barrel pump was used, the spraying outfit consisted of a three and one half barrel tank, shown in Fig. 1, mounted upon a two wheeled cart of 7 foot tread (the wheels are from an old mower) carrying a Morrill & Morley pump with two lines of hose, the whole drawn by two horses

* Bulletin 102.

hitched to walk midway of the spaces between rows of cucumbers. For its manipulation three men and team are required; one man to drive and pump, and one to each line of hose. After the vines were larger it was found convenient to use the bamboo rods with shut off, and at all times a double Vermorel nozzle was used on each side. Each man sprayed half the row, astride which the cart was driven, and the next full row on his side. In this manner three full rows were sprayed at each drive across the field. Later in the season the vines were pruned by a disk cutter, so as to leave a one-foot space in which man and horse were free to walk. This system of planting lends itself more readily than another to the outfit and procedure here outlined. Suggestions covering narrower planting have already been made in Bulletin 89.

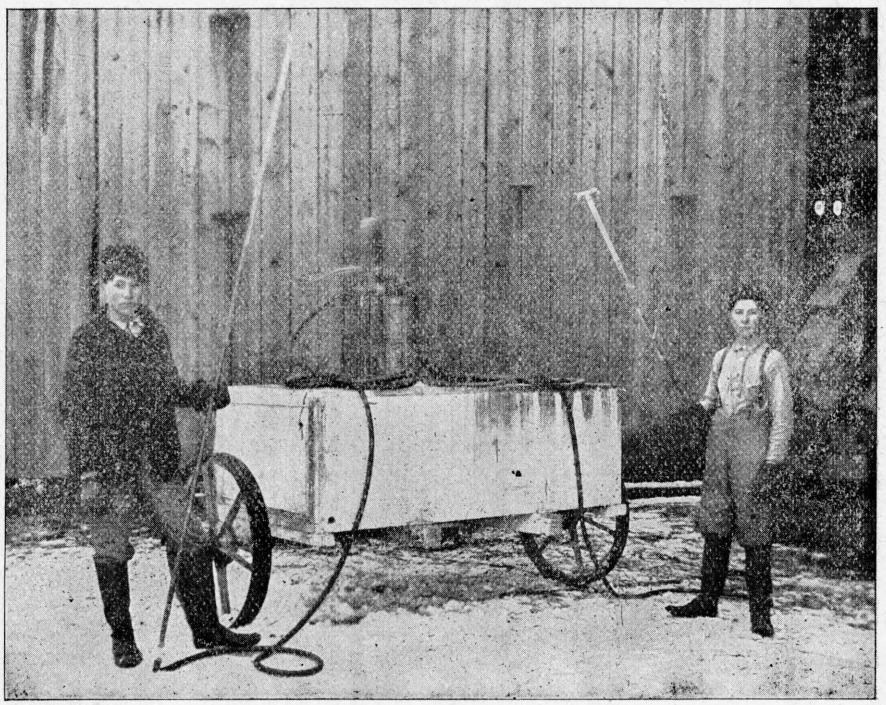

Fig. 1. Spray cart of 7 foot tread, belonging to Dr. A. C. Knestrick, with pump and attachments used in the cucumber experiments. The tank is counterpoised by quadrant shift. (From a photograph taken in winter.)

TABLE II — SHOWING AREA AND LABOR COST OF SPRAYING CUCUMBERS AT CRESTON, 1898.

Spraying and Date.	Total Area Sprayed.	Total hours for Crew.	Barrels of Bordeaux Mixture.	Pounds Copper Sulfate used.
First — July 18-20	13.5	30.	13	52
Second — August 1-4	14.	31.	32	128
Third — August 12-16	15.	36.	47	188
Fourth — August 23-24	9.	16.	23	92
Fifth — Aug. 31, Sept. 2	13.	27.5	35	140
Sixth — September 7-8	9.	17.5	23	92
Average second to sixth inclusive	12	25.6	32	128

COST PER ACRE.

	Acres Sprayed per hour.	Hours of Crew per acre.	Barrels of Mixture per acre.	Pounds of Copper Sulfate per acre.
First	.62	2.2	0.96	3.9
Second	.66	2.2	2.3	9.2
Third	.48	2.4	3.1	12.4
Fourth	.58	1.8	2.5	10.2
Fifth	.56	2.1	2.7	10 8
Sixth	.58	1.9	2.5	10.2
Average second to sixth inclusive	.57	2.1	2.6	10.56

It appears that it cost in this case on an average, for spraying pickle vines in full leaf, 2.1 hours of labor for three men and team, or the whole crew, to spray an acre, while at the same time 2.6 barrels of Bordeaux mixture per acre was required, containing in this amount 10.6 pounds of copper sulfate and the same amount of lime. The cost per acre of the work and materials, in money estimates, for each spraying in full foliage (the only sort required for downy mildew) will be as follows:

2.6 barrels of Bordeaux mixture @ 25 cts	$ 0 65
2.1 hours for crew @ 45 cts	95
Total	$ 1 60

But, basing judgment upon the outcome of these experiments, not more than five sprayings will be made for this disease. These will cost, on the basis given above, when done with the great thoroughness which was pursued in this work, $1.60 x 5—or $8.00 per acre for the season.

TABLE III — SHOWING YIELD OF SPRAYED AND UNSPRAYED CUCUMBER PICKLES IN FIELD OF DR. A. C. KNESTRICK, CRESTON.†

Date of Picking.	Plot I. Unsprayed. Rows 5 and 6. Bushels.	Plot II. Sprayed. Rows 7 to 46. Bushels.	Portions of Plot II, on Rows 7 and 8. Bushels.	
.....	.....	.....	.....	Pickings previous to August 18 are not credited here.
August 18	3.*	51	3.*	
" 19	.....	55	.....	
" 20	1.75	16	3.	
" 22	.....	65	.....	
" 25	5.75	79	5.75	
" 26	.....	10	.....	
" 27	1.25	.....	1.5	
" 28	.....	60	.....	
" 31	5.	.....	8.	
September 1	.....	106	.....	
" 3	.....	80	1.5	
" 6	.....	90	1.5	
" 7	.....	15	.5	
" 8	.....	5	.....	
Total	16.75	622.	25.	
Average per row	8.38	15.52	12.5	
Yield per acre	88.	163.	134.	

* Rows 5-8 not taken separately on July 18.

† Some pickles were gathered earlier than August 18; not here included.

From Table III. it will be seen that there was, after August 18, an average yield of 8.38 bushels per row on unsprayed rows 5 & 6 (Plot I) or 88 bushels per acre; on two rows to south and adjacent (Nos. 7. & 8) 12.5 bushels per row or 134 bushels per acre; while the average yield on 40 rows, 7 to 46 inclusive (Plot II) was 15.5 bushels per row or 163 bushels per acre. Since the mildew spread from the unsprayed rows, 5 & 6, to two adjacent, 7 & 8, more than to others, the latter yield, 163 bushels per acre, seems more correct as a comparison of sprayed with unsprayed than that of rows 7 & 8 only. The double comparison was chosen by reason of possible shade influence from wood at north. This gives an increase of 75 bushels per acre for sprayed pickle areas over unsprayed. For the current season, about one-half the pickles were under four inches in length and of the grade which brought 45 cents per bushel at the salting houses; the other half were "slicers' in the trade and sold at 15 cents per bushel. The gross return of sprayed pickle vines was accordingly $22.50 per acre more than from unsprayed. Since the vines were practically exhausted before the spraying of September 7 & 8 was made, and this was done to discover how long they might be preserved, we may properly charge against this as follows:

Credit, 75 bushels of pickles @ 30 cts.....		$22 50
Debit, Picking same @ 12½ cts.....	$9 37	
Spraying, 5 times.....	8 00	
		17 37
Leaving a net profit to spraying of.....		$5 13

This is clearly not a large margin and admits of reasonable explanations.

First: the weather was so favorable to the growth of cucumber vines, and the difficulty to secure pickers so great, that the proportion of large pickles rose to one-half instead of one-fifth as it is in ordinary seasons.

Second: this growth of large cucumbers, with many altogether missed reduced the vitality and productiveness of the vines so low that production in a measure ceased at the end of the first week in September.

Thus the yield was crowded into a short period and the time during which the favorable effect of spraying could operate with profit shortened to one-half that of previous seasons. Doubtless the lesson is as clear as if the profits were larger. The fact has already been mentioned that early planted cucumbers gave in 1898 a fine pickle yield without spraying. This was rendered possible by the phenomenally early date at which the harvest was closed. Such conditions cannot arise every year; the essential point is that the spraying with Bordeaux mixture, as claimed for it, preserved the vines from serious injury by the downy mildew. While the sprayed vines ceased to produce a crop of pickles about September 6 to 8, they were still green and but slightly injured by mildew September 20th; the unsprayed vines were practically dead September 2.

LESSONS OF THE EXPERIMENTS IN SPRAYING FOR MILDEW.

The chief lessons are: No practical difference between vines sprayed six times and those on which the first spraying was omitted; omission of spray after August 1, is not advised. Unsprayed plots are too much risk in commercial spraying for downy mildew. The spread of the disease is so rapid that it will undoubtedly occur and be extended by picking, by travel in the field or by the wind. This was well shown at the Station, when sprayed and unsprayed plots were run transversely across the rows of different varieties, while the pickers necessarily followed these rows. Although the mildew appeared first only upon unsprayed plots, the pickers aided its spread to all the areas. And further it may be again urged that downy mildew may be escaped if early planting and harvesting prove remunerative.

The results of those who planted early, May 10, and did no spraying, and of those who planted about June 10, and tried the Bordeaux mixture to prevent mildew, were apparently satisfactory to the growers concerned. Mr. C. Z. Yoder, of Weilersville, had an average yield of 226 bushels per acre on 6 acres; he stopped picking September 5th and reports much

difference between the vines sprayed last on the 20th of August and those last treated August 25th, and both contrasting with those last sprayed August 13th. Dr. A. C. Knestrick had an average yield of 228 bushels per acre on 14 acres sprayed cucumbers; while Mr. Harter had double this yield per acre on a single acre of early planted pickles.

MUSKMELON SPRAYING.

It has seemed within a few years as if profitable muskmelon growing had ceased to be possible in Ohio; indeed the finer market nutmegs were drawn for a year or two from remote localities outside the State. Therefore attention was directed to discover whether muskmelon growing might be made profitable by spraying.

Unfortunately, we have several factors in the muskmelon problem that are different from those affecting cucumbers or cucumber pickles, and, at the same time, these elements vary among themselves. They belong to two classes—

First: the fungous parasites of the muskmelon, in their various relations, and second: the market conditions incident to abundant supply, and consequently the low prices of muskmelons which prevail at the critical season for the grower's vines. Even if spraying were to save the melon vines it is not clear that it would prove a paying investment for the midseason crop, because the prices then rule very low.

Taking into consideration these features of the matter, it was scarcely hoped that the muskmelon problem could be solved in a single season, or that all spraying experiments were likely to yield favorable results. The failures, in fact, have outnumbered the successes in muskmelon spraying, though one or two decided successes indicate a possible victory in the end. Here, as with cucumbers, the critical period is rather late, so that if beginning is made early courage to spray to the end is occasionally altogether wanting. In this work the writer was assisted by Mr. Howard Lennon, of Canal Lewisville, O.; Mr. Leroy Rose, of Trinway, O.; Mr. C. P. Dyar, of Marietta, O., and Messrs. R. J. & E. S. Tussing, of Canal Winchester, O. Messrs. Rose and Dyar conducted coöperative experiments, the others carried out similar plans entirely at private expense.

ANTHRACNOSE OF THE MUSKMELON.

About June 15, Mr. Howard Lennon, of Canal Lewisville, reported by telephone that his muskmelon vines were showing serious disease, and sought advice. It seemed probable, from the description given of symptons, that Mr. Lennon had to deal with a case of anthracnose (*Colletotrichum Lagenarium*) so that spraying with Bordeaux mixture was advised. The field was visited June 21st, and apprehensions were then fully confirmed. The plants were of the Tip-Top variety, which had been grown in pieces of sod under cover in hotbed and transplanted in the field, a sandy loam, May 24th and May 28th. They grew well, were in

a warm and highly enriched soil, and gave promise of satisfactory development. About June 14th spots on stems and disease of borders of young leaves were observed. The action then taken has been stated. Mr. Lennon began spraying June 20th, repeating the treatment two and three times. The results were entirely satisfactory as far as the anthracnose was concerned. It was noted that very early spraying in cool weather caused yellowing of the leaves. July 19th the condition of the field was good; only 5 to 8 per cent. of hills showed impairment of vigor by the disease, where treatment had been made. On check rows, untreated, a great deal more of the disease was apparent. August 20th the field began to show serious injury from leaf blight (*Alternaria*) and downy mildew (*Plasmopara*); no spraying had been given since previous visit. Unsprayed rows had about died out from anthracnose. Another muskmelon field, where Early Hackensack was grown, had completely died down at this date from mildew and leaf blight. The yields from the Tip-Top area were quite good, but the quality deteriorated later. Those plants grown from seed in place had little anthracnose or were not at all diseased. A few plants left in cold frame were much worse diseased than those transplanted to the field; it is apparent that the disease must have started here and was carried to the field at transplanting.

DOWNY MILDEW AND LEAF BLIGHT OF MUSKMELONS.

Arrangements were made for a coöperative trial of spraying in a field of Mr. Rose of Trinway. Mr. Rose is an experienced muskmelon grower, and it was confidently believed that no person better qualified than he could be selected; he, moreover, kindly agreed to aid in the work and took a great interest in the experiments. Here a field of late nutmegs was chosen. These were planted rather late, in mellow, sandy, bottom soil. A moderate growth was secured, though thorough cultivation was not given and the field later became foul with weeds. Spraying was begun July 15th and was repeated about July 25th and August 17th, yet not with such thoroughness as in the cucumber spraying at Creston. August 20th this field was half dead from downy mildew; on the 17th, when last sprayed, a few hills only were reported spotted, yet on the 20th the result was serious. Few melons had ripened; they were of the Gem variety. Melon vines among high weeds were as badly attacked by mildew here as in cleaned areas. A very little Alternaria was collected, though the vines were destroyed by downy mildew. The spraying done showed no good effects.

Mr. R. J. Tussing, of Canal Winchester, O., an experienced gardener, cultivated an area of one and one half acres in muskmelons of Tip-Top and Early Hackensack varieties, chiefly the former. These were carefully sprayed with Bordeaux mixture at intervals of 10 to 14 days. The vines were maintained in healthy condition almost or quite

till frost came. Indeed, as with the cucumbers at Creston, the vines of the Tip-Top sort ceased to produce after exhausted by crop, and continued green for several weeks afterwards; those of Hackensack variety were less free from disease. The yield was very good and much of it was marketed at good prices. A notable fact was that the melons here continued of first quality so long as any were produced, while on vines which became spotted with mildew the melons were insipid and unsatisfactory. Mr. Tussing's prices were maintained for some time because he could *guarantee quality*. Mr. E. S. Tussing, of the same place, made a similar test of spraying, but left unsprayed plots, which were not left in the field of Mr. R. J. Tussing. The results were not entirely satisfactory, though slightly favorable to spraying. Mr. C. P. Dyar sprayed about 1 acre of muskmelons, June 22d, July 8th and July 23d. I quote his report. —"The sprayed rows appeared to be much the best for some time, but following the last spraying came hot, steamy weather and all blighted together in a few days. As only a few of those grown could be sold, no account of the yield was kept." "It appears that nothing can stop the blight when the weather is favorable enough."

So far as we studied, both Alternaria and Plasmopara were found on these diseased vines. Upon sprayed and unsprayed melon vines at the Station mixed results were obtained. One check section, the only one free from other complications, was injured by the spray at a critical time; however it was green later and more vigorous than unsprayed plots. Some yellowing and apparent checking of growth was observed on early muskmelons, sprayed during cool weather in June. The same yellowing was noted in several localities, here and elsewhere, upon vines receiving no treatment with Bordeaux mixture. It will be observed that a warning on this point has been inserted in the new spray calendar (Bulletin 102). Early spraying during cool weather can scarcely be recommended. On the whole, we cannot conclude that the use of Bordeaux mixture for the fungous parasites of the muskmelon has proven a decided success. The partial success of one or two growers, the complete success of a single experienced one and the utter failure of the later crop upon nearly all grounds, where unsprayed, leaves the matter somewhat as follows:—

A limited crop of very early muskmelons upon early soil may be grown by transplanting and harvested without spraying; the later melons on such vines are almost certain to be rendered worthless by attacks of disease upon the vines.

Late muskmelons, or late yields from early vines, cannot apparently be secured without spraying for fungous diseases, but no one can hope for success in this line without great thoroughness in spraying, beginning for southern Ohio, as early as July 20th and for northern situations not later than August 1st. This spraying can be of most value when in con-

junction with the best cultivation and general care. Muskmelons are attacked by leaf blight, anthracnose wilt and downy mildew, all of which, save the first, are found upon cucumbers.

WATERMELON DISEASES.

What has been stated about occurrence of leaf blight and downy mildew upon muskmelons applies also to watermelons. These have died off from mildew, following the cucumbers and muskmelons under observation, and before pumpkins, squashes, gourds and other cucurbits were as badly injured. In addition, a leaf spotting cercospora, *Cercospora Citrullina* Cooke, has been found here the present season upon watermelon leaves.

TOMATO BACTERIAL AND LEAF BLIGHTS.

What was stated in previous bulletins (Bulletins 73 and 89) need not be repeated here, though still of its original force. The original illustration of tomato leaf blight fungus, *Septoria Lycopersici* Speg., is here reproduced, to save detailed descriptions. While the bacterial disease which is common to the tomato, egg-plant and potato, and causes much rotting and dying of stems and branches of tomato plants has been locally destructive as in previous seasons, the leaf blight trouble has caused two or three times more injury in 1898 than was noted in any previous season. About Columbus, Lancaster, Clyde, Marietta and doubtless other places, it has caused a great reduction of the late tomato crop which meets the wants of seedsmen, canners and pulp-makers.

During the season of 1898 the conditions of warmth and moisture seemed to favor the development of the Septoria fungus to an unusual extent. In addition to attacking leaves and stems and defoliating the plants, save for a very small group of leaves of newest growth, this fungus is reported by Mr. Miesse, at Lancaster, to have destroyed fruitfulness by attacking the calyx. It was noted in Bulletin 89 that after the stems become attacked by the fungus there is failure to set fruit; whether this failure be primarily due to the one or the other attack—whether because the stem or the calyx is infected—or whether because of both, the result is the same; there is almost total loss of crop. Mr. Miesse reports one-third the usual crop; the Clyde growers and canners one-third to one-fourth a full crop, and others suffered in like measure. The experiment referred to in the bulletin just quoted, supported by the experience of other Stations, leaves little doubt as to the efficiency of Bordeaux mixture to prevent the leaf blight; the effects upon staked tomatoes are certainly conclusive.

During seasons like the past one there is little doubt of a right balance from spraying the field, unstaked crop, but in a season like that of 1897 the profit might not be so large. I fear that leaf blight has come to be a permanent menace to tomato growing, and that its effects will be so unequal in different seasons that growers will not easily reach a

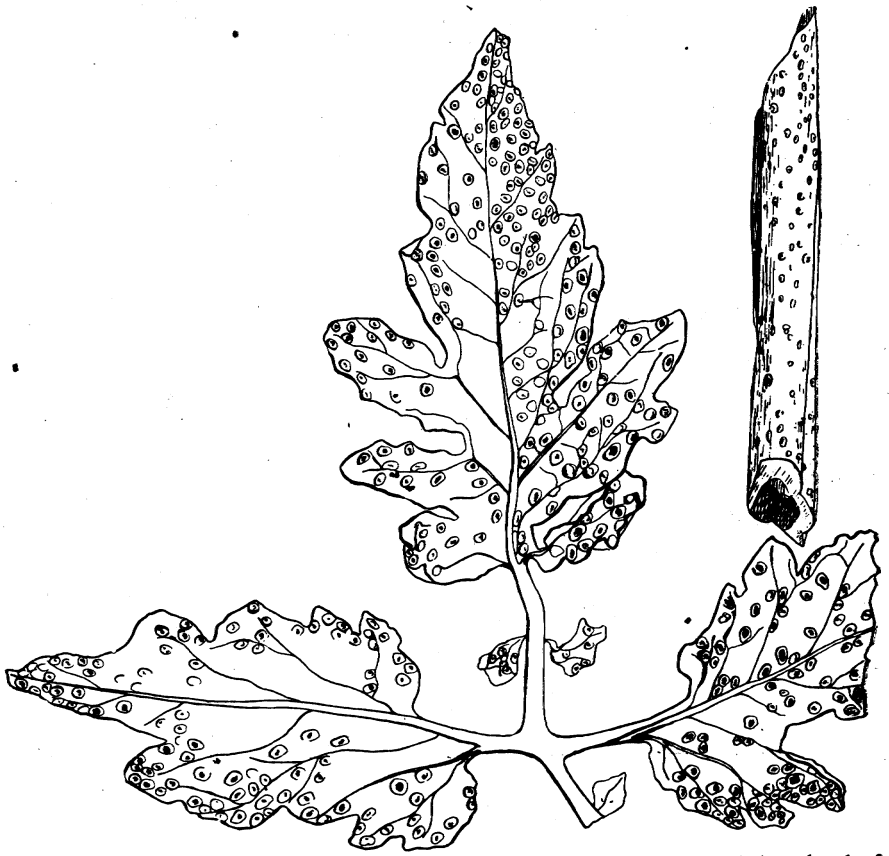

Fig. 2. Tomato leaflets and section of tomato stem, spotted by the leaf blight fungus, *Septoria Lycopersici* Speg. The leaves attacked either drop off or die hanging to the stem. This trouble may be expected in southern Ohio as early as July 1, but not till two or three weeks later in the northern portions of the state. (From Bulletin 73.)

well-grounded practice in dealing with it. The only experiment for the season is one by Mr. C. P. Dyar, of Marietta, upon very early, staked tomatoes. The results are given by him as follows:—

"REPORT OF SPRAYING EXPERIMENTS WITH TOMATOES."

"Plants were grown under canvas and transplanted to the field May 19. All grew finely. The ground was heavily manured before plowing and also manure was put in the rows. There were 11 rows, of 150 plants each. Ten rows were sprayed June 8, June 21, and July 23. The season was dry until about July 1, then turned wet and was continually hot and steamy, with unusually heavy rains in August. The Bordeaux mixture was used. It stuck to the vines well and heavy and continuous rains did not seem to make much impression on it. It required some extra labor to wash it from the tomatoes when packing them for market. They were packed in the ordinary fruit baskets, holding two-fifths of a bushel. My vines grew well, kept green much longer than those of my neigh-

bors who did not spray, and there was for a long time a small though noticeable difference between the sprayed and the unsprayed row, though the unsprayed row in my patch held its leaves longer than those of my neighbors. The vines were yet full of tomatoes when the market refused to take them at any price. Probably about as many rotted as were sold. The corn boll worm also did serious damage. Early in August all the vines blighted alike and the leaves fell off. The warm, wet weather, however, soon produced a new growth, and they continued to grow until heavy frost came last week. The stems of the vines did not blight very much. In former years they also died early. I have no figures of production from my neighbor's vines to make a comparison; but the experiment leads me to think that the vines can be preserved to some extent and the total crop yield enlarged; but as our profit depends only on the sale of the very early ones, and as some blight appears to hasten maturity, it is doubtful if spraying is profitable here. Longer experiments would be needed to settle this point.

"Ten sprayed rows produced 243½ baskets an average of 22 1-7 baskets.

"The unsprayed row produced 23½ baskets.

"[The last tomatoes marketed were gathered August 1.]"

"C. P. DYAR."

"Marietta, Ohio, October 28, 1898."

Some spraying work at the Station was carried on by Professor Green but the absence of leaf blight left the issue without interest.

In Mr. Dyar's case, it will be perceived how the problem of *early market* in his region may make the leaf blight a benefit by causing earlier fruitfulness, while for the canner, on the other hand, the late crop is profitable. When visited July 22d the unsprayed row showed decided injury from leaf blight, all leaves, except about one an one-half to two feet at the summit, being dead and dry. September 21st no difference was apparent between sprayed and unsprayed vines. Where the harvest will warrant spraying, Bordeaux mixture can still be recommended without reservation for the prevention of leaf blight of the tomato.

SUMMARY.

The cucumber pickle industry continues to increase in Ohio and the yields of pickles have been more satisfactory for 1898 than for the previous year. The abundant rains, well distributed, and the high mean temperatures for the growing months have contributed to this end.

The downy mildew of cucumbers and allied plants, *Plasmopara Cubensis,* has been fully as destructive to the plants during the season named as in 1897, but owing to the earlier harvesting of the crop the actual reduction of yields has been only about one-half as great from this cause.

Anthracnose of cucurbits, *Colletotrichum Lagenarium,* has increased in abundance and destructiveness. A wilt of cucumbers and muskmelons, referred to a species of *Fusarium,* has also prevailed, besides the usual wilt disease. *Phyllosticta Cucurbitacearum* and *Cercospora Cucurbitae* have also been found spotting cucumber leaves as well as *Cercospora Citrullina* upon watermelon foliage.

Coöperative spraying experiments upon a commercial scale have given an increase of 75 bushels per acre upon sprayed, compared with unsprayed cucumber pickle vines, attacked by downy mildew. The profits from this treatment were not so large as would have accrued from similar work in 1897, for reasons pertaining to earliness of crop.

The practicability of saving the late crop of cucumbers from downy mildew, by use of Bordeaux mixture, is fully demonstrated by the experiments made. Spraying for this purpose need not be begun earlier than July 25 to August 1. If a crop of pickles or cucumbers is harvested by August 15th, spraying for downy mildew is not required.

Spraying for anthracnose, downy mildew and leaf blight of muskmelons is still recommended, although some failures are recorded.

Previous recommendations as to the treatment of late tomato plants with Bordeaux mixture to prevent tomato leaf blight, *Septoria Lycopersici*, are again repeated.

PUBLICATIONS

OF THE

OHIO AGRICULTURAL EXPERIMENT STATION.

A complete list of previous publications of this Station may be found in Bulletin 95. Following are the titles of subsequent bulletins:

No. 96. The Army Worm and other insects; Wheat and Grass Sawflies; the Corn or Boll Worm; the Painted Hickory Borer; the Raspberry Cane Borer; the Peach Scale.

No. 97. Diseases of wheat and oats.

No. 98. Small fruits; cultural notes and comparison of varieties.

No. 99. Sugar beet investigations in 1898.

No. 100. A comparison of factory-mixed and home-mixed fertilizers.

No. 101. Experiments with oats.

No. 102. Soil and seed treatment and spray calendar for insect pests and plant diseases.

No. 103. The San José Scale in Ohio.

No. 104. Further studies upon spraying peach trees and upon diseases of the peach.

No. 105. Further studies of cucumber, melon and tomato diseases.

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